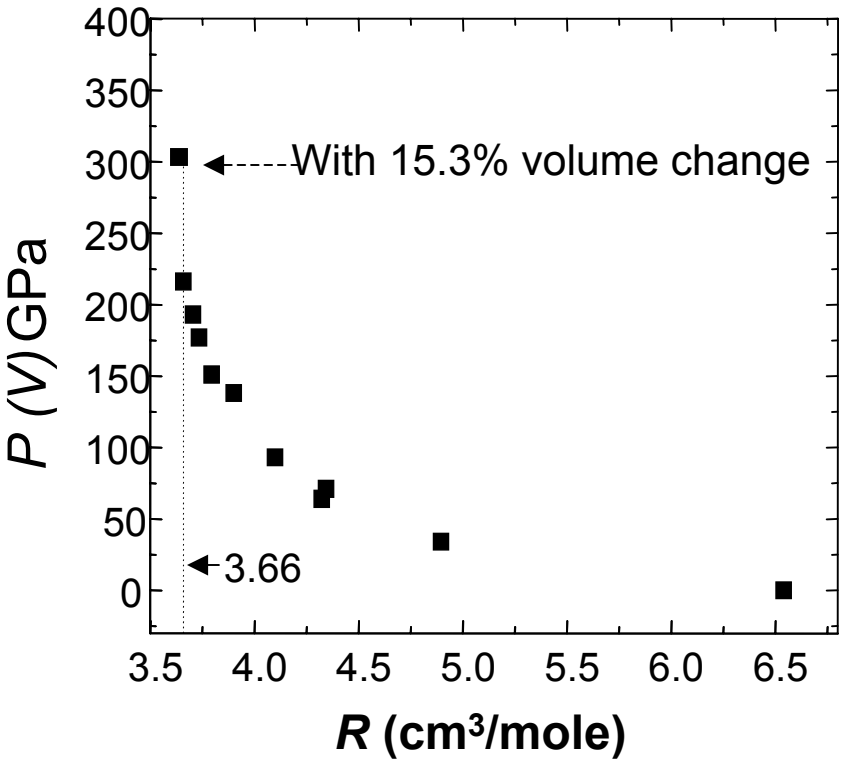
Optical Studies of Methane to 301 GPa: A New Semiconductor

Arthur L. Ruoff, Cornell University, DMR-0304745

Methane (natural gas) is a vital energy source. In studies to 301 GPa we find: (1) that it's molar refraction, R, decreases substantially from 6.541 to an asymptotic value of 3.66 at high pressure, unlike the behavior of high atomic number materials, Xe and BaTe, where R is a constant (this in the first case where R has been obtained as a function of ultrapressure); (2) that CH4 at 301 GPa is a semiconductor whose n and k values (of the complex refractive index n + ik) are very close to silicon. If CH4 behaves further like silicon, then a 10% volume decrease to a pressure of 360 GPa would lead to a first order transition with a 20.9% decrease in volume and metallization. The metal is expected to be a superconductor with a very high Tc.



Molar refractive R as a function of pressures showing the approach to an asymtotic value

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Education:

It has been my privilege to further the education of my Research Associate, Dr. Liling Sun. In making semiconducting methane at 301 GPa, she and the P.I. have achieved a phase transition at the highest static pressure ever. These results were presented in a graduate course taught by the P.I.

Societal Impact:

The next step in this research is to extend the pressure so methane metallizes (as we did earlier for xenon, oxygen, sulfur, etc.) and then to check for superconductivity. Methane according to calculations could be the superconductor with the highest superconducting transition pressure.